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Results of the 1997 Fleming Survey of demersal juvenile cod in the coastal zone of eastern Newfoundland

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Abstract

The 1997 Fleming Survey for juvenile cod in coastal Newfoundland was conducted at the same sites, at the same time of year, and with the same sampling gear and protocol as in previous years. It was executed by local fishermen and one travelling scientist. The 1997 Fleming Survey was conducted between 23 September and 27 October. The primary objective was to assess annual change in abundance of 0-, 1- and 2-group cod in shallow water nursery areas of the east and northeast coasts. A total of 1828 juvenile cod (1645 0-group; 126 1-group; 57 2-group) were collected at 38 sites between St. Mary's Bay and western Notre Dame Bay. This is the highest mean catch of 0-group cod collected on any Fleming Survey since the cod moratorium began in 1992. The high mean catch of 0-group cod in 1997 was associated with high 95% confidence limits indicating a high contrast in catches among sites. 0-group cod were highly aggregated with 70.3% being caught in 3 tows at just two sampling sites. Highest catches of all age classes occurred in Trinity Bay. Catches of 1-group cod were low in 1997, a finding compatible with the historically low catches of 0-group cod collected in 1996 (mean=6.7 cod/tow). The high catch of 0-group cod in 1997 is predicted to result in high catches of 1-group cod in 1998. In addition, the high catch of 0-group cod in 1997 and the historically low catch of 0-group cod in 1996 provides two consecutive and contrasting yearclasses that may result in a detectable recruitment signal in subsequent years as the relatively poor 1996 and stronger 1997 yearclasses recruit. This is the second year that inshore fishermen have participated in the Fleming Survey and with sampling juvenile cod in coastal habitats. The willingness of fishermen to help and their interest in juvenile cod, and knowledge of the local area/conditions result in a fishermen based survey being a good way to sample small cod in coastal habitats. Conducting the Fleming Survey with fishermen in 1996-1997 puts in place a fishermen based framework for conducting the survey in future years.

Résumé

Le relevé de Fleming de 1997 visant les morues juvéniles des eaux côtières de Terre-Neuve a été réalisé aux mêmes lieux, au même moment de l'année, avec les mêmes engins et suivant le même protocole que les années antérieures. Il a été réalisé par les pêcheurs locaux et un scientifique en déplacement, entre le 23 septembre et le 27 octobre. Il avait pour objectif premier l'évaluation de la variation annuelle de l'abondance des morues des groupes 0, 1 et 2 dans les zones de croissance à eau peu profonde des côtes est et nord-est. Au total, 1 828 morues juvéniles (1 645 du groupe 0, 126 du groupe 1 et 57 du groupe 2) ont été prélevées en 38 endroits situés entre la baie St. Mary's et l'ouest de la baie Notre Dame. Il s'agit de la capture moyenne la plus élevée de morues du groupe 0 faite dans le cadre du relevé de Fleming depuis l'imposition du moratoire en 1992. La capture moyenne élevée de morues du groupe 0 de 1997 présentait des limites de confiance à 95 % élevées ce qui indique une forte variation entre les sites. Les morues du groupe 0 étaient fortement concentrées, 70,3 % des poissons ont été capturés en 3 traits de chalut en seulement deux lieux de prélèvement. Les captures les plus élevées de toutes les classes d'âge ont été faites dans la baie Trinity. Les captures de morues du groupe 1 ont été faibles en 1997, ce qui est cohérent avec le faible niveau historique de capture de morues du groupe 0 obtenu en 1996 (moyenne de 6,7 morues par trait). Les captures élevées de morue du groupe 0 de 1997 devraient se traduire par des captures élevées de morues du groupe 1 en 1998. Les captures élevées de morues du groupe 0 de 1997 et les faibles captures de morues du groupe 0 de 1996 constituent deux classes d'âge consécutives très différentes qui pourraient donner lieu à un signal de recrutement décelable au cours des années suivantes sous la forme du recrutement d'une classe d'âge faible en 1996 et d'une autre importante en 1997. Les pêcheurs côtiers participaient pour la deuxième année au relevé de Fleming et à l'échantillonnage de morues juvéniles dans les habitats côtiers. La volonté des pêcheurs à collaborer au relevé et l'intérêt qu'ils portent aux morues juvéniles, alliés à leurs connaissances de la région et des conditions locales font qu'un relevé faisant appel à leurs services est un bon moyen d'effectuer un échantillonnage des petites morues dans les habitats côtiers. La participation des pêcheurs au relevé de Fleming en 1996 et 1997 constitue le fondement d'un cadre à leur collaboration au cours des prochaines années.

Objective

The **overall objective** of the 1997 Fleming Survey is to determine the change in mean abundance of 0-, 1-, and 2-group demersal juvenile cod at sites in the coastal zone of eastern Newfoundland. This survey was initiated in 1959 by A. Fleming and T. Collier (of the Department of Fisheries and Oceans, [DFO] St. John's). The survey was conducted from 1959-1964 by DFO and from 1992-1997 by the Ocean Sciences Centre (OSC), Memorial University of Newfoundland (MUN).

Gear, Methods and Sampling Locations

When the Fleming Survey was initiated in 1959-1964, it was essentially a ship based survey conducted from the MV PARR, a longliner and research vessel of the Department of Fisheries and Oceans. The PARR served as a base for sampling the catch, as a home for the scientists while in the field, and as a means of transportation between sites. From 1992-1995 the Fleming sites were sampled from a 6.1 m fibreglass boat powered by a 45 horsepower outboard motor. This boat was towed by truck and trailer from site to site. The boat was launched at a slipway close to the site to be sampled. When sampling was completed the boat was loaded onto a trailer and moved to the next site.

In 1996-1997 the sampling protocol was modified such that local fishermen became an integral part of the survey. Fishermen provided a boat, motor, and a second individual to help with the sampling. Fishermen also provided important knowledge of the local area, for example where underwater obstructions were located. Fishermen evaluated whether conditions were suitable for motoring to the sampling site and whether conditions were likely to be suitable upon arrival at the site. Fishermen helped with deployment and retrieval of the seine as well as with sampling the catch. The same fishermen who helped with the survey in 1996 also volunteered their time in 1997. A total of 13 fishermen and helpers participated in the 1997 survey (Appendix I). Fishermen were reimbursed for gasoline expenses.

Special attention was given to each of the following to ensure that past and present surveys were as similar as possible: i) locating the sampling sites, ii) gear specifications, iii) gear deployment and sampling design, and iv) time of sampling.

Locating Sampling Sites

Fleming Sites were relocated in 1997 by fishermen who participated in the survey in 1996 (Fig. 1). The same sites were resampled in 1997 to within a few metres of where sites were sampled in 1996. The one exception was site 52 in Gander Bay where, we were not able to sample as high up on the beach because of the very low tide. Therefore sampling in 1997 was conducted about 20 m (to the south) from where it was conducted in 1996. All sampling sites are described and located in the 1996 Fleming Survey Report which includes charts and station records used during the 1959-1964

surveys. Copies of this report are located in the Memorial University of Newfoundland library as well as at the Department of Fisheries and Oceans library in St. John's.

Gear Specifications

The fishing gear used to sample juvenile cod in 1959-1964 and 1992-1997 was a 25 m seine. This seine was hauled by two people towards the shore after being deployed from a small boat. This seine has a headrope length of 24.4 m and a footrope of 26.2 m. The wings, belly, and codend were constructed of knotless nylon netting, 19 mm stretch mesh in the wings and belly, and 12.7 mm stretch mesh in the codend. The codend was lined with a knotless nylon netting of 9 mm stretch mesh. The Dan Leno Sticks at the end of each wing of the seine where the two hauling ropes are attached were 75 cm long and 25 mm in diameter and made of aluminum, not oak as previously used in 1959-1964. Descriptions of the gear and its deployment are given in Lear et al. (1980) and Schneider et al. (1997). Deployment of the seine is described in detail in the 1996 Fleming Report. The seine fishes a standardized area of 16 m (along the shore) by 55 m (offshore) = 880 m^2 on each tow. Where possible, three standardized tows were conducted at each site. The first two tows sampled the same 880 m^2 with the time between tow 1 and 2 being about 30-45 minutes. The third tow was conducted immediately adjacent to the first two tows, just 16 m further along the shore.

Time of Sampling

Three sets were made at each site. The fish from each set were kept separate and were not returned to the water until after all three sets were completed. Fish were identified and measured. All sampling was conducted during daylight hours regardless of the tidal stage.

Present day (1992-1997) sampling is similar to historical (1959-1964) sampling in that the same sites were sampled at almost exactly the same time each year (Table 1). The number of sampling sites varied each year (Table 2). The two start-up years (1959 and 1960) had the lowest number of sites sampled. Weather was an important determinant of the number of sites sampled in 1997. We tried to maintain a sampling schedule in 1997 such that the same sites were sampled on approximately the same date ($\pm$ 2-3 d) each year (Table 1). However the 1997 survey started and finished later than previous years by about one week.

Other Sampling

Fish were measured for standard length (SL) in the field at the completion of the third tow. Whenever possible, fish were returned alive to the water. Standard length was used to divide the catch into three length groups (LG's) as defined by clear modes in the catch from several types of fishing gear deployed previously to sample juvenile cod in shallow water along the coast of Newfoundland (Methven and Schneider 1998).

Age groups, as estimated from size modes were:

LG0 = 96 mm SL or less
LG1 = 97-192 mm SL
LG2 = 193-290 mm SL.

Figure 2 shows that the length modes of juvenile cod from the 1996 and 1997 Fleming Surveys were similar to the size classes listed above that were used in previous surveys to estimate age. Two length modes were evident in the 1997 Fleming Survey. One mode at ca. 50 mm SL, with the second at ca. 150 mm SL (Fig. 2). These modes, where data are available, were generally observed in each bay sampled (Fig. 3).

Bottom temperature was taken at each site at the maximum depth sampled by the seine at 55 m distance from the shore. This point was marked by a surface float that was tossed overboard as the codend of the seine was being deployed on the first tow. Once the third tow was completed and we were preparing to leave the site, the boat came along side the float. Temperature was recorded by a Vemco temperature recorder after being deployed for one minute (accurate to 0.1°C). Depth was determined using a weighted line marked at 0.25 m intervals.

Results and Discussion

The 1997 Fleming Survey was conducted with the same gear (25 m beach seine), at the same time of year (September-October), and at the same sites that were sampled in previous years to ensure comparability of the survey among years.

A total of 2723 juvenile cod (22 to 327 mm SL) were collected from 38 sites sampled (n=75 sets) on the 1997 Fleming Survey (23 September to 27 October). 1828 of these (n=1645 0-group; n=126 1-group; n=57 2-group) were collected in the first two tows at each site. The remaining 895 cod were collected on the third tow. The mean catch per tow (first two tows) was 21.9 0-group, 1.6 1-group, and 0.76 2-group cod. This represents the highest catch of 0-group cod since the cod moratorium began in 1992 (Table 3; Fig. 4). This is a substantial increase in mean catch of 0-group from 1996 (factor of 3.2) when catches were the lowest in the 12 year history of the survey. This high contrast in mean catches of 0-group cod between two consecutive years (1996, 1997) may result in a detectable recruitment signal as these year classes recruit to the fishery. Predictions that arise from this high contrast in catches (0=group: 1996 LOW; 1997 HIGH) during two consecutive years (1996, 1997) are:

1997 - low abundance of 1 year olds (observed this year; Table 3, Fig. 4),
1998 - high abundance of 1 year olds, low abundance of 2 year olds,
1999 - high abundance of 2 year olds.

If this recruitment signal propagates as cod recruit to the fishery then this should result in **1996 being a poor year class** and **1997 being a good year class** relative to each other.

The higher mean catch of 0-group cod in 1997 (Table 3) was also associated with higher 95% confidence limits around the mean (Fig. 4). High variation around the mean reflects highly variable catches among sites, with a few sites containing most of the 0-group cod that were caught. An examination of the catch data in the text table below indicates how aggregated 0-group cod are: i.e. 1156/1645=70.3% of all 0-group cod were caught in three tows at two sites in Trinity Bay (site 27 [tow 1, n=214, tow 2, n=735]; site 34 [tow 2, n=167]). 1997 is comparable to 1996 when three tows accounted for 398/610 = 65.24% of the 0-group cod caught.

catch range	**number of tows within range**	**number of 0-group cod**
0	29	0
1-10	31	90
11-99	11	399
>99	3	1156
	-------	----
	75 tows	1645

The recruitment signal observed in the Fleming data analyzed up to and including 1994 (Schneider et al. 1995, Ings et al. 1997) was observed when 1-group cod catches were regressed against 0-group cod catches for data up to and including 1997 (Table 4, Fig. 5). A significant relation was observed for LG1 cod regressed against LG0 cod when tow data were ln(n+1) transformed (due to the presence of zero catches at many of the sampling sites) and when the regression was weighted by the inverse of the variance of the LG1 catch. This regression was significant when both tows at each site were used ($p=0.0175$, Table 4) or when just a single tow was used at each site ($p=0.0127$, Table 4).

These regressions, whether conducted using one or two tows, relate the number of LG0 cod with the number of LG1 cod the next year, i.e. $LG1 = Ke^{-zt}LG0$, where Ke^{-zt} represents the relative survival from one year to the next ($t=1$) and where K = the efects of other factors such as catchability. Examination of the Fleming data provided in the text table below for the 1959-1963 and 1992-1996 yearclasses (ages 0 and 1) shows that Ke^{-zt} is very high during the first winter when age 0 cod make the transition to one year olds. This is a time when survival has been shown to be low for several species of freshwater and marine fishes (Oliver and Holeton 1979, Cunjak and Power 1987, Post and Evans 1989, Miranda and Hubbard 1994).

K may include factors such as the catchability of LG1 relative to LG0 cod. For the 25 m seine the ratio of the catchabilities $\alpha_{LG1} / \alpha_{LG0}$ should be nearly constant. A second factor that can influence the catch rates of these age classes (and hence the ratio of LG1 to LG0 cod) is the annual change in the area occupied by LG1 cod relative to LG0 cod (A_{LG1}/A_{LG0}). Both length groups are abundant in shallow water nearshore however LG1 cod do appear to spread out more, occupy deeper depths offshore and thus occur over a larger spatial extent. This means that LG1 cod are not as confined to the nearshore zone as are LG0 cod (Dalley and Anderson 1997). Therefore the 25 m seine which samples the immediate nearshore zone, likely catches a higher proportion of the LG0 cohort than the LG1 cohort. It is not known if this ratio is constant, but there is some indirect evidence that the ratio of areas occupied may be related to cohort size (Schneider et al. 1997).

Yearclass	**LG0**	**LG1**	**Index of relative survival (Ke^{-zt})**
1959	177.8	133.9	0.74
1960	31.3	27.6	0.87
1961	10.9	6.9	0.63
1962	29.5	30.7	1.04
1963	17.8	50.7	2.85
1964	9.5		
1992	9.5	10.2	1.07
1993	9.1	16.4	1.8
1994	19.7	1.1	0.05
1995	13.2	2.4	0.18
1996	6.7	1.6	0.23
1997	21.9		

A third factor that can influence the ratio of LG1 to LG0 cod within a cohort (yearclass) is variation in the fraction of LG0 cod that have settled by the time that the survey is conducted. If the number of LG0 cod is increasing during this period due to settlement (for example) while the number of LG1 cod is decreasing due to an offshore seasonal movement (for example) then these age specific migrations will have an important influence on the ratio of LG1 to LG0 cod and hence be an important contributor to any estimate of yearclass strength, mortality, or survival.

At present none of these factors (catchability, differential spreading of the age classes, and variation in the fraction of LG0 cod that have settled by the time that the survey is conducted) are well known or quantified. Catchability has been estimated to be high for LG0 cod caught by the 25 m seine (60-98% determined by SCUBA diving observations and by the Leslie Method - Hilborn and Walters 1992). Catchability for the 25 m seine has not been estimated for LG1 or LG2 cod. The rates of migration into and out of the zone sampled by the seine during the time that the Fleming Survey is

conducted are not known. It is know that settlement by LG0 cod generally increases from September to October and that the abundance (availability to the seine) of LG1 cod decreases by November (Methven and Bajdik 1994) likely due to cod moving offshore into deeper water. Thus the general directions of the movements are known or suspected but the rates have not been quantified.

The LG1*LG0 regression was conducted on all data up to and including the one year olds caught in 1997 (1996 yearclass). The 1993 data were corrected to account for the presence of *G. ogac* in the samples. *Gadus ogac* is morphologically similar to *G. morhua* at small sizes. These two species were not distinguished from each other in 1993 unlike other years. Consequently, the mean abundance of cod (*G. morhua*) estimated from the 1993 survey is too high. Fortunately, intact samples taken during the 1993 survey were available and in good condition as frozen specimens. These were identified to species and the results summarized in Table 5. The value for the mean catch of 0-group cod (the size range where the identification problem is greatest) in 1993 is approximately 30% too high and should be reduced from 13.25 to 9.17 0-group cod per tow, assuming that the proportion of *G. ogac* from the five samples listed in Table 5 is representative of the proportion of these two species encountered throughout the survey.

Juvenile cod distribution at the scale of major bays along the coast of Newfoundland was generally the same as in previous years (Fig. 6). Catches of 0-group cod were highest in Trinity Bay with catches to the south (St. Mary's and Conception Bays) and to the northwest (Gander Bay-New World Island and Notre Dame Bay) being less (Fig. 6). Mean catch of 1-group cod in 1997 was also highest in Trinity Bay. This is a slight departure from previous years when highest catches of this age class generally occurred in St. Mary's and Conception Bays (Fig. 6). Trinity Bay once again had the highest mean catch of 2-group cod, while Notre Dame Bay (as in 1996) had the second highest catches.

1997 was the second year that the Fleming Survey was conducted with the help of inshore fishermen. The advantages of a fishermen based survey were outlined in the 1996 Fleming Report and our thinking on this has not changed. The willingness of fishermen to help and their interest in juvenile cod, and knowledge of the local area/conditions result in a fishermen based survey being a good way to sample small cod in coastal habitats. Conducting the Fleming Survey with fishermen in 1996-1997 puts in place a fishermen based framework for conducting the survey in future years.

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Table 1. Duration of sampling for juvenile cod by year and bay in eastern Newfoundland in 1959-1964 and in 1992-1996. SMB=St. Marys Bay, TB=Trepassey Bay, CB=Conception Bay, TB=Trinity Bay, BB=Bonavista Bay, NDB=Notre Dame Bay. NDB includes Gander Bay and New World Island. Sites are located in Figure 1.

Bay\Year	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**
SMB	----	12 Sep	08 Sep	17 Sep	19 Sep	19 Sep
&TB		20 Sep	14 Sep	21 Sep	25 Sep	25 Sep
CB	2 Oct	28 Sep	21 Sep	26 Sep	5 Oct	24 Sep
	8 Oct	29 Sep	23 Sep	27 Sep	7 Oct	25 Sep
TB	10 Oct	3 Oct	25 Sep	1 Oct	10 Oct	29 Sep
	12 Oct	4 Oct	30 Sep	14 Oct	12 Oct	3 Oct
BB	16 Oct	6 Oct	3 Oct	11 Oct	17 Oct	6 Oct
		10 Oct	7 Oct	16 Oct	19 Oct	8 Oct
NDB	23 Oct	17 Oct	9 Oct	17 Oct	21 Oct	12 Oct
	26 Oct	27 Oct	24 Oct	26 Oct	31 Oct	22 Oct
Bay\Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
SMB	22 Sep	22 Sep	23 Sep	21 Sep	19 Sep	23 Sep
&TB	23 Sep	23 Sep	27 Sep	23 Sep	29 Sep	
CB	28 Sep	28 Sep	29 Sep	28 Sep	28 Sep	2 Oct
	29 Sep	29 Sep	4 Oct	29 Sep	5 Oct	
TB	20 Sep	30 Sep	30 Sep	30 Sep	1 Oct	7 Oct
	6 Oct	6 Oct	6 Oct	7 Oct	4 Oct	11 Oct
BB	8 Oct	8 Oct	7 Oct	8 Oct	5 Oct	18 Oct
	9 Oct	9 Oct	8 Oct	9 Oct	6 Oct	
NDB	14 Oct	14 Oct	14 Oct	14 Oct	13 Oct	20 Oct
	21 Oct	21 Oct	22 Oct	20 Oct	22 Oct	27 Oct

Table 2. List of Fleming Sites sampled each year with at least two consecutive sets of fishing effort within two hours. One site (site 18) was sampled by only one haul of the 25 m seine in 1997.

Location	Site No.	1959	1960	1961	1962	1963	1964	1992	1993	1994	1995	1996	1997
Harricot Beach	1			X	X	X	X	X	X	X	X	X	
Half Island	2				X	X		X	X	X	X	X	X
Mother Hicks Cv	3							X	X		X	X	X
Admirals Beach	4		X	X	X								
Mosquito Cove	5		X	X		X	X	X	X			X	X
North Harbour	6			X	X		X	X	X	X	X	X	X
Trepassey	10				X	X	X	X	X	X	X	X	X
Cape Broyle	12		X		X	X	X						
Davies Head (N)	16	X	X	X		X		X	X	X	X	X	
Davies Head (S)	17	X	X	X	X			X	X	X	X	X	X
Crockers Cove	18	X	X	X	X			X	X	X		X	X
Bryants Cove	19	X	X	X	X	X	X	X	X	X		X	X
Bristols Hope Cv	20	X	X	X	X	X	X	X	X	X		X	X
Rantem Cove	25			X	X	X	X						
Masters Head	26							X	X	X	X	X	X
Little Mosquito Cv	27			X	X	X		X	X	X	X	X	X
Bald Point Beach	28			X	X			X	X	X	X	X	X
Long Beach (E)	29		X				X	X	X	X	X	X	X
Long Beach (W)	30				X		X	X	X	X	X	X	X
Lower Lance Cove	31			X	X	X	X						
Middle Lance Cv	32				X		X	X	X	X	X	X	X
Burgoynes Cove	33					X	X	X	X	X	X	X	X
Lockston's Arm	34	X	X	X	X	X		X	X	X	X	X	X
Cap Cove	35					X	X	X	X	X	X	X	X
Cannings Cove	40		X	X	X	X	X	X	X	X	X	X	
Man Point	41		X		X		X	X	X	X	X	X	
Great Chance Hbr.	43				X	X							
Great Chance Hbr.	44				X	X	X						
Eastport	45			X	X		X						
Indian Bay	46		X	X	X	X		X	X	X	X	X	X
Rubens Cove	50				X	X	X	X	X	X		X	X
Grassy Island	51			X		X		X	X	X	X	X	X
Seal Island	52					X	X	X	X	X	X	X	X
Fox Island	53				X	X	X	X	X	X	X	X	X
Bridgeport	57		X		X	X	X	X	X		X	X	X
Luke's Arm	58		X	X	X	X		X	X		X	X	X

Table 2. con't. List of Fleming Sites.

Location	Site No.	1959	1960	1961	1962	1963	1964	1992	1993	1994	1995	1996	1997
Fortune Hbr.	65		X			X		X	X	X	X	X	X
Fortune Hbr.	66							X	X				
Fortune Hbr.	67			X		X		X	X	X	X	X	X
Fortune Hbr.	68			X	X	X		X	X	X	X	X	X
Fortune Hbr.	69				X	X		X	X		X	X	X
Wild Bight	70			X	X	X		X	X	X	X	X	X
Julies Hbr.	71				X	X	X	X	X	X	X	X	X
Tommy's Arm	72			X	X	X	X	X	X	X	X	X	X
Woodfords Arm	75			X	X	X	X	X	X	X		X	X
Woodfords Arm	76			X		X	X	X	X	X		X	
Woodfords Arm	77			X		X		X	X	X		X	
Lower Wolfe Cove	78			X	X	X	X	X	X	X	X	X	X
Green Island	79						X		X	X	X	X	X
Beachy Cove	80			X	X	X	X	X	X	X	X	X	X
Shimmey Cove	81			X	X	X	X	X		X		X	X
Little Bay Arm	82				X	X	X						
Middle Arm	83					X							
Middle Arm	84		X			X		X	X	X	X	X	X
King's Point	85			X	X	X	X	X	X	X	X		

Table 3. Summary of the number of hauls (NHAUL) and mean catch (cod/haul) by year for LG0, LG1, and LG2 juvenile cod collected at Fleming Sites along the northeast coast of Newfoundland. This table summarizes all data where two consecutive sets were conducted at each site. The number of sites sampled in any year with two consecutive sets = NHAUL / 2. One site in 1997 (Crockers Cove [site 18] in Conception Bay) was sampled by only one haul of the 25 m seine.

Year	Nhaul	LG0	LG1	LG2
1959	12	177.8	5.1	1.5
1960	34	31.3	133.9	0.5
1961	60	10.9	27.6	2
1962	80	29.5	6.9	0.8
1963	82	17.8	30.7	0.4
1964	64	9.5	50.7	2
1992	92	9.5	3.9	0.3
1993	88	9.1	10.2	0.2
1994	80	19.7	16.4	0.9
1995	72	13.2	1.1	0.2
1996	90	6.7	2.4	0.5
1997	75	21.9	1.6	0.7

Table 4. Summary statistics of regressions of LG1 on LG0 and LG2 on LG1 cod. All values were ln(n+1) transformed. The regressions were weighted by 1/variance (WLG). Regressions are done on corrected data for 0-group cod in 1993. Two regressions were conducted, one regression using only tow 1 data, with the second using both tow 1 and tow 2 data at each site.

---------- NTOWS=1 ----------

Dependent variable: MLG1
Weight: WLG1

Source	**df**	**Sums of squares**	**Mean square**	**F**	**Pr > F**
Model	1	6.0416742	6.04167421	9.62	0.0127
Error	2	6.0007933	0.66675481		
Corrected total	10	12.417535			

Paramater	**Estimate**	**T**	**Pr > |T|**	**Error**
Intercept	-1.7033	-1.81	0.1038	0.9414
Mcount0	2.1214	3.1	0.0127	0.6839

---------- NTOWS=2 ----------

Dependent variable: MLG1
Weight: WLG1

Source	**df**	**Sums of squares**	**Mean square**	**F**	**Pr > F**
Model	1	5.44479	5.44479	8.43	0.0175
Error	2	5.81549	0.64617		
Corrected total	10	11.2603			

Paramater	**Estimate**	**T**	**Pr > |T|**	**Error**
Intercept	-1.7754	-1.75	0.1143	1.01538
Mcount0	2.17633	2.9	0.0175	0.74973

Table 4. Continued for regressions of LG2 on LG1 cod.

---------- NTOWS=1 ----------

Dependent variable: MLG2
Weight: WLG2

Source	**df**	**Sums of squares**	**Mean square**	**F**	**Pr > F**
Model	1	0.21122	0.21122	4.7	0.0621
Error	8	0.35979	0.04497		
Corrected total	9	0.57101			

Paramater	**Estimate**	**T**	**Pr > |T|**	**Error**
Intercept	0.12698	2.01	0.079	0.63095
Mcount1	0.08148	2.17	0.0621	0.0376

---------- NTOWS=2 ----------

Dependent variable: MLG2
Weight: WLG2

Source	**df**	**Sums of squares**	**Mean square**	**F**	**Pr > F**
Model	1	0.13338	0.13338	2.18	0.178
Error	8	0.48939	0.06117		
Corrected total	9	0.62278			

Paramater	**Estimate**	**T**	**Pr > |T|**	**Error**
Intercept	0.13074	1.95	0.0865	0.06692
Mcount1	0.05868	1.48	0.178	0.03974

Table 5. Number of *G. ogac* and *G. morhua* identified from five sites sampled during the 1993 Fleming Survey.

Site	Number of *G. ogac*	Number of *G. morhua*
34	83	188
46	48	64
20	58	147
40	13	84
78	21	19
Totals	223	502

% *G. ogac* = 223/725=30.7%
% *G. morhua* = 502/725=69.2%

Appendix I. Fishermen who participated in the 1997 Fleming Survey.

#	Beach name	Fisher	Location
2	Half Island	Bernard Power	North Harbour
3	Mother Hicks Cove	" "	" "
5	Mosquito Cove	" "	" "
6	North Harbour	" "	" "
10	Trepassey	Don and David Corrigan	Trepassey
17	Davies Head North	OSC/MUN	
18	Crockers Cove	OSC/MUN	
19	Bryants Cove	OSC/MUN	
20	Bristols Hope Cove	OSC/MUN	
26	Masters Head	OSC/MUN	
27	Little Mosquito Cove	OSC/MUN	
28	Bald Point Beach	OSC/MUN	
29	Long Beach East	OSC/MUN	
30	Long Beach West	OSC/MUN	
31	Lower Lance Cove	Dennis Ivany	Petley
32	Middle Lance Cove	" "	"
33	Burgoynes Cove	" "	"
34	Lockstons Arm	Tom Toope	Trinity
35	Cap Cove	" "	"
46	Indian Bay	Gerard Shaw	Indian Bay
50	Rubens Cove	Isaac Whitt	Fredericton
51	Grassy Island	" "	"
52	Seal Island	" "	"
53	Fox Island	" "	"
57	Bridgeport	Lindy and Lloyd Rideout	Cottlesville
58	Lukes Arm	" " "	"
65	Fortune H (NW Bottom)	Edward and Glen Butler	Cottrells Cv.
67	Fortune H (Fox Cv 2)	" " "	" "
68	Fortune H (SW Bottom)	" " "	" "
69	Fortune H (SE Bottom)	" " "	" "
70	Wild Bight	Hayward and Cory Strickland	Pilleys Is.
71	Julies Harbour	" " " "	" "
72	Tommys Arm	" " " "	" "
75	Woodfords Arm (outer)	Westly and Chad Caravan	Miles Cove
78	Lower Wolfe Cove	Clyde and Almo Oxford	Springdale
79	Green Island	" " "	"
80	Halls Bay	" " "	"
81	Shimmey Cove	Gerald Bouzanne	Little Bay
84	Middle Arm	Wallace Budgell	Middle Arm

List of Figures

Figure 1. Map of Newfoundland showing sites sampled by two consecutive hauls of the beach seine in 1959-1964 and 1992-1997. Sites 1-10 are in St. Mary's and Trepassey Bays, 16-20 in Conception Bay, 25-35 in Trinity Bay, 40-46 Bonavista Bay, 50-53 Gander Bay, 57-58 New World Island, 65-85 Notre Dame Bay. Refer to Appendix I for sites sampled in 1997.

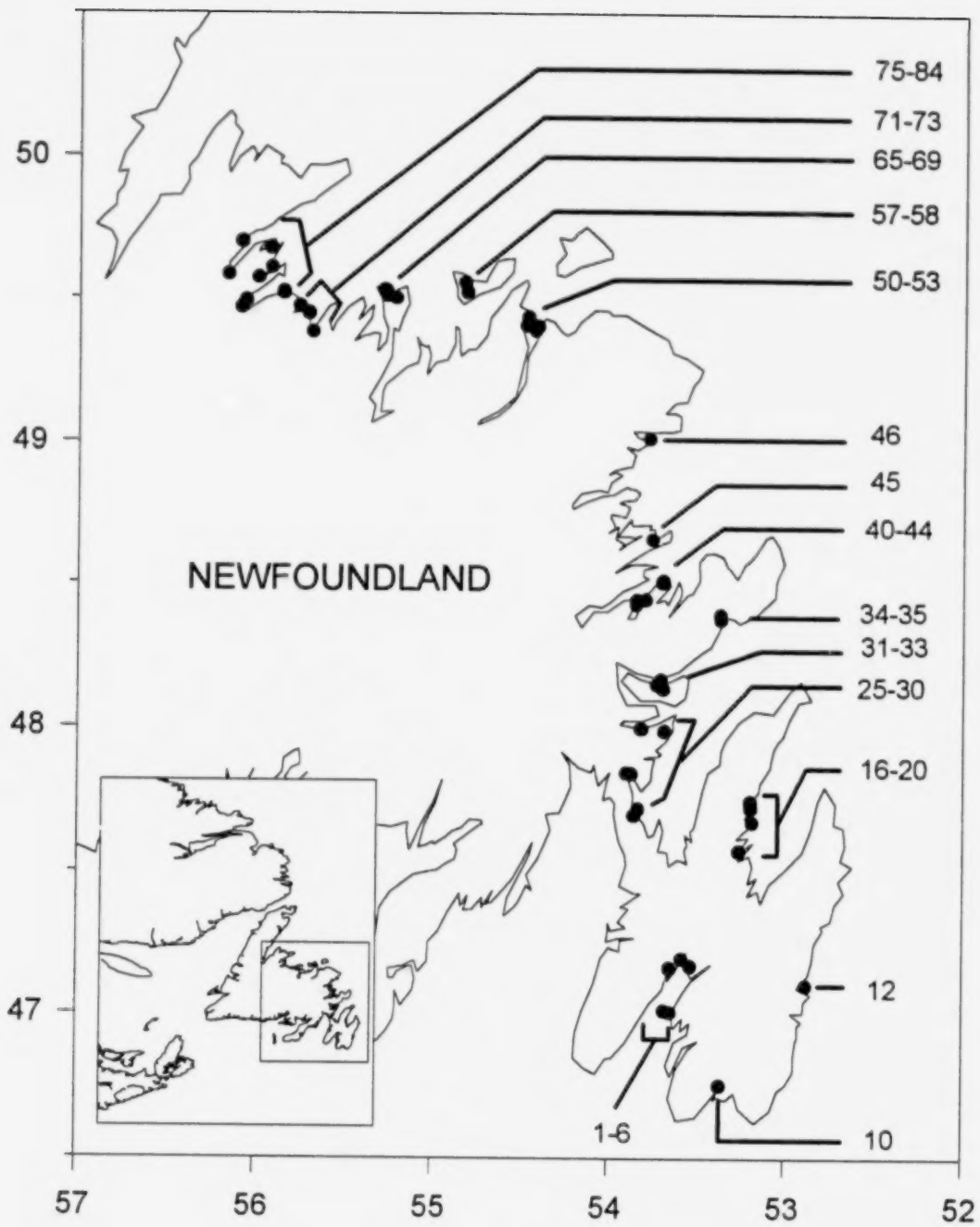
Figure 2. Length frequency of juvenile cod collected in 1996 and 1997. Number of cod per 3 mm SL size class from all three tows at each site are shown.

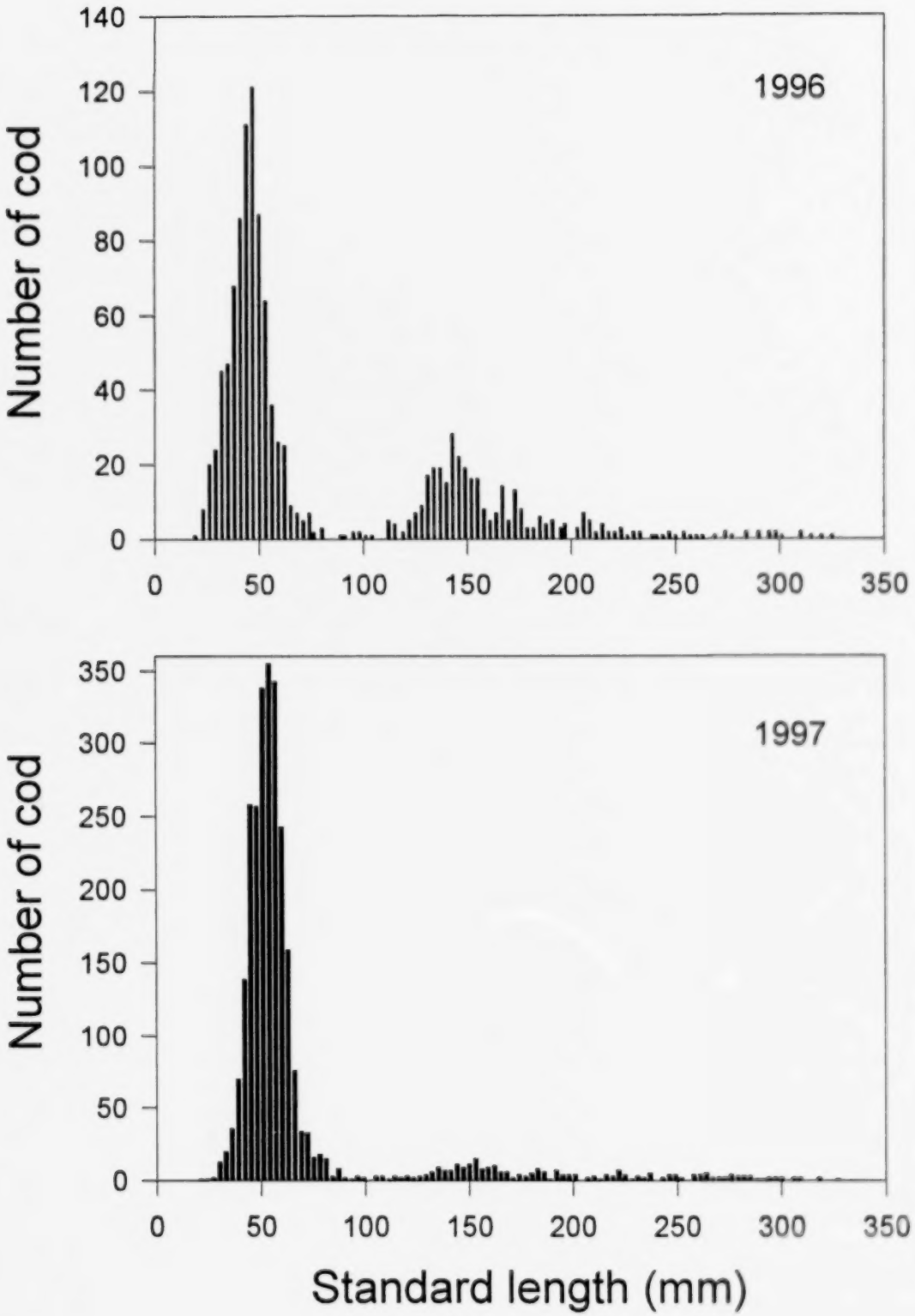
Figure 3. Length frequency of juvenile cod collected by bay in 1997. Number of cod per 3 mm SL size class from all three tows at each site are shown.

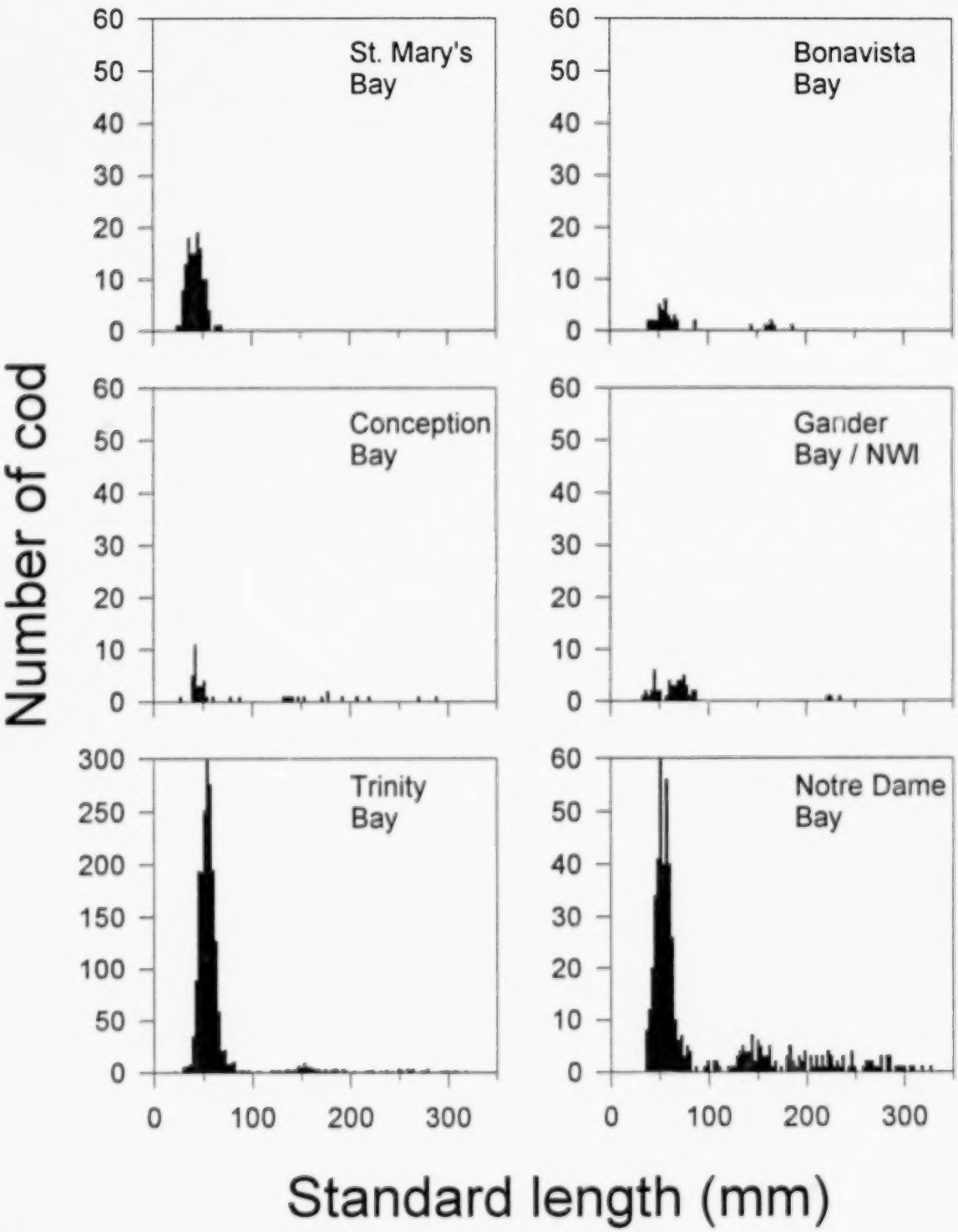
Figure 4. Mean catches of LG0, LG1, and LG2 cod in 1959-1964 and 1992-1997. 95% confidence limits were computed by repeated resampling (bootstrap) methods.

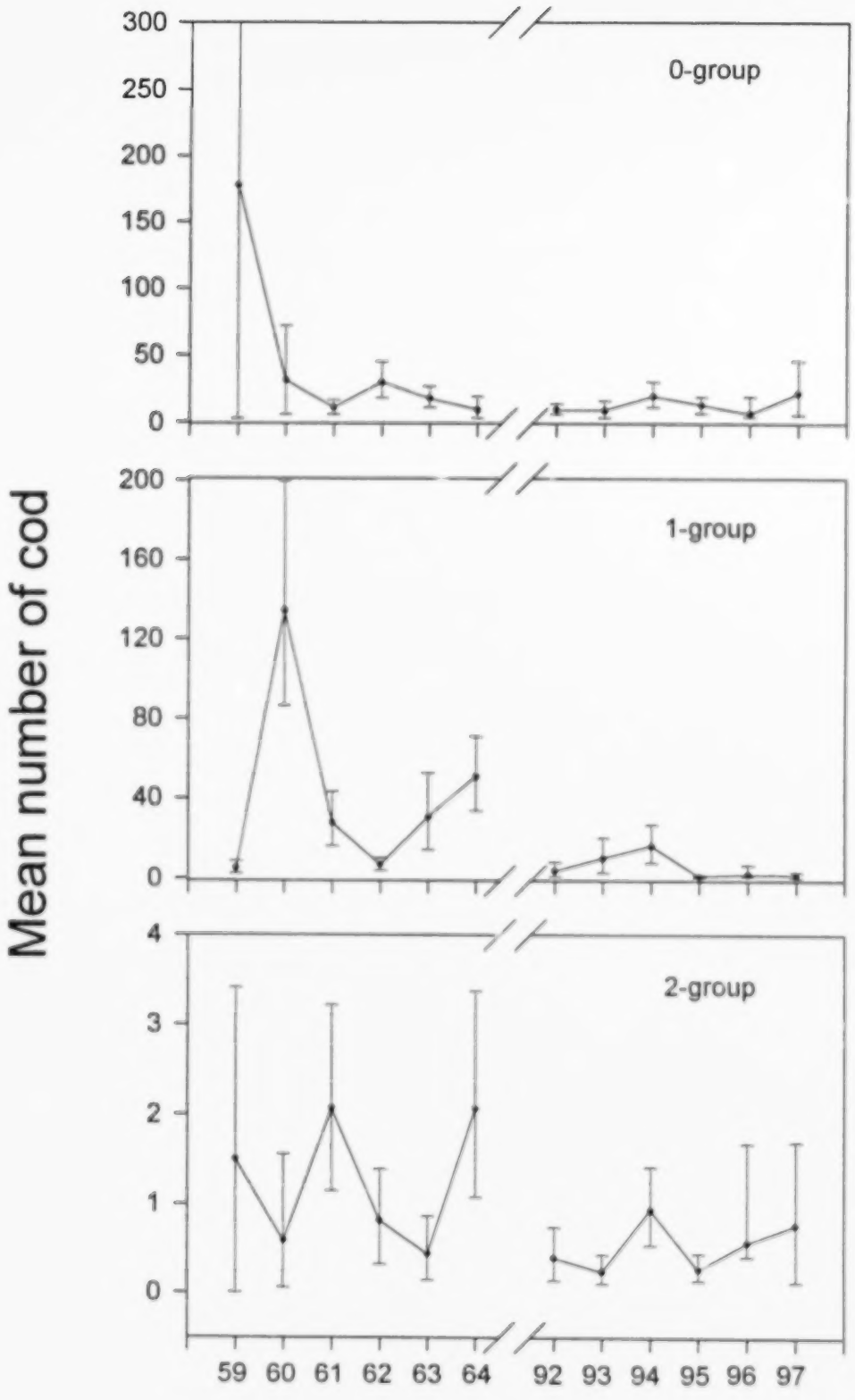
Figure 5. Mean catches of LG1 cod plotted against LG0 cod and similarly for LG2*LG1 cod. O = one tow; T = two tows. Regressions that accompany this figure are summarized in Table 4.

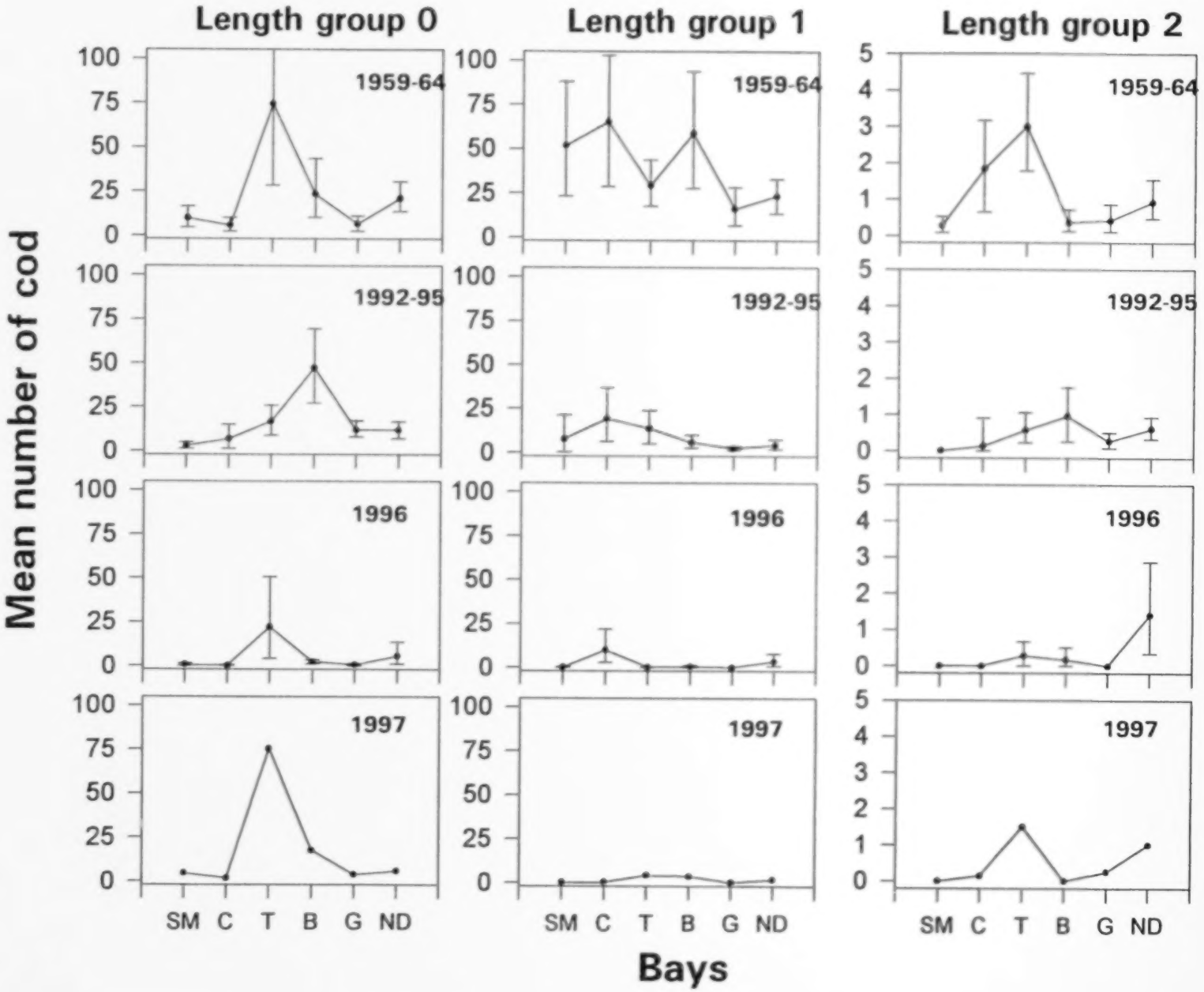
Figure 6. Mean catch of juvenile cod from historic (1959-1964), recent (1992-1995), 1996, and 1997 Fleming Surveys in six continuous sections of coast. 95% confidence limits were computed by repeated resampling (bootstrap) methods. SM=St. Mary's Bay, Trepassey Bay and Southern Shore, C=Conception Bay, T=Trinity Bay, B=Bonavista Bay, G=Gander Bay and New World Island, ND=Notre Dame Bay.

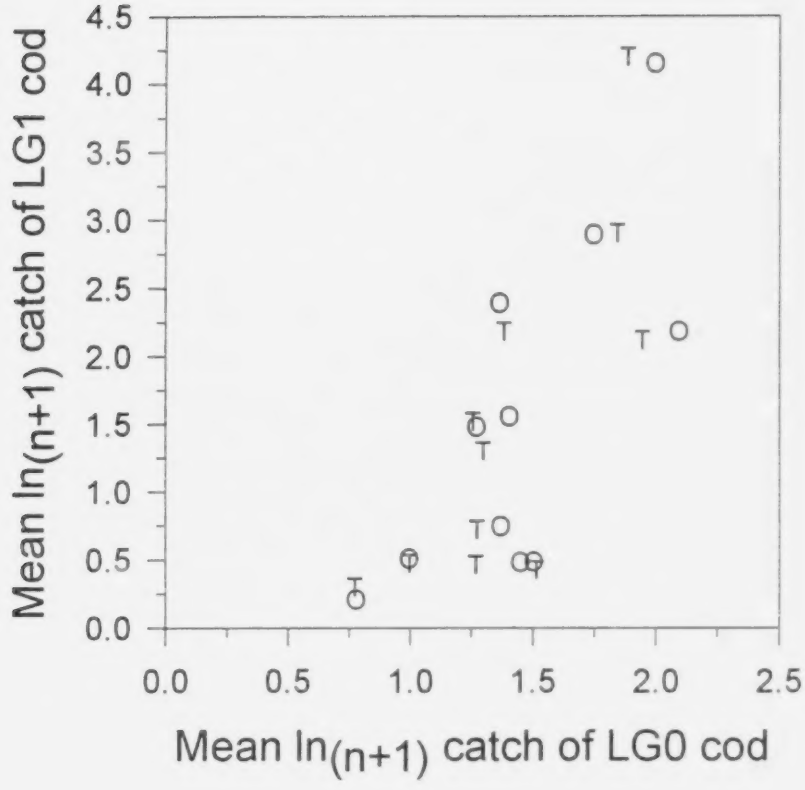

75-84
71-73
65-69
57-58
50-53
46
45
40-44
34-35
31-33
25-30
16-20
12
10
1-6
NEWFOUNDLAND
50
49
48
47
57
56
55
54
53
52

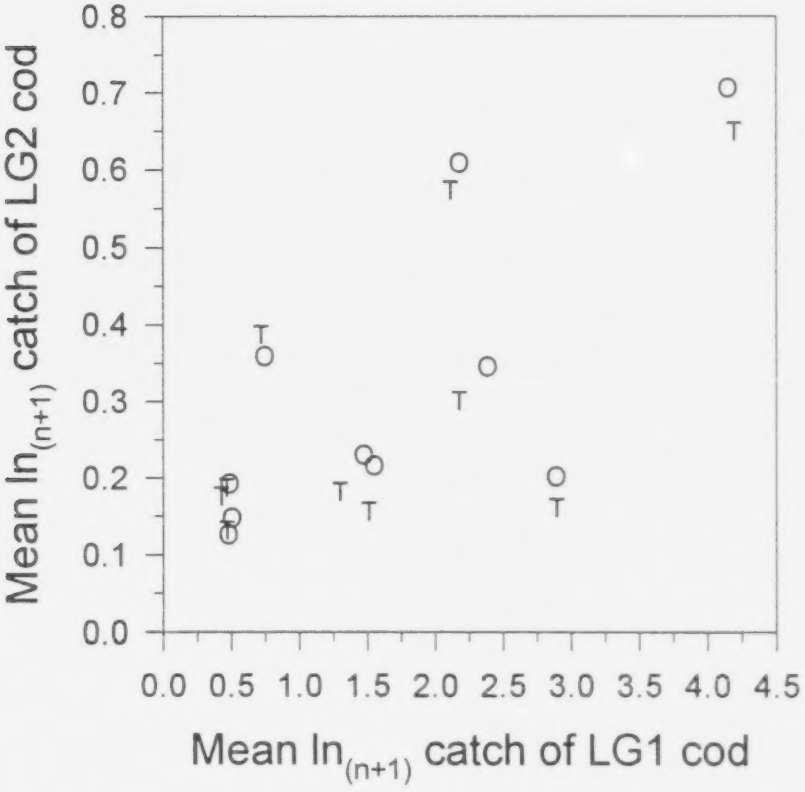

1996
1997
Number of cod
Number of cod
Standard length (mm)
0
20
40
60
80
100
120
140
0
50
100
150
200
250
300
350


St. Mary's Bay
Bonavista Bay
Conception Bay
Gander Bay / NWI
Trinity Bay
Notre Dame Bay
Number of cod
Standard length (mm)
0
10
20
30
40
50
60
100
150
200
250
300


Mean number of cod
0-group
1-group
2-group
300
250
200
150
100
50
0
200
160
120
80
40
0
4
3
2
1
0
59 60 61 62 63 64 92 93 94 95 96 97


Length group 0
Length group 1
Length group 2
Mean number of cod
1959-64
1992-95
1996
1997
SM C T B G ND
Bays


Mean ln(n+1) catch of LG1 cod
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
Mean ln(n+1) catch of LG0 cod


Mean ln(n+1) catch of LG2 cod
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Mean ln(n+1) catch of LG1 cod